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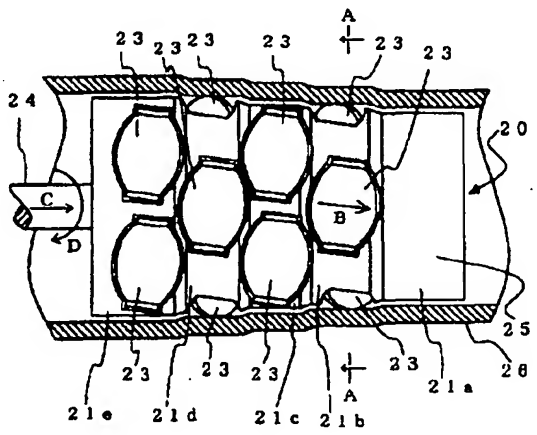
(54)【発明の名称】　拡管マンドレル及びこれを用いた長尺管の拡管方法

(57)【要約】
【課題】鋼材による長尺管を拡管するに際し、小さい摩擦抵抗でエネルギー効率良く、しかも寸法精度にも優れた加工を行うことのできる拡管マンドレル及びそれを用いた長尺管の拡管方法を提供すること。
【解決手段】鋼材による長尺管２６の一方の開口端より拡管マンドレル２０を挿通し、この拡管マンドレル２０を前進回転させながら拡管マンドレル本体２５の外周面に設けられる複数の拡径ローラ２３、２３・・・を長尺管２６の内壁面に圧接させ、その長尺管２６の径方向外方へ押し広げて拡径する。



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【特許請求の範囲】

【請求項１】　鋼材による長尺管に挿通される拡管マンドレル本体の外周面に、該長尺管の内壁面に圧接され、かつ、その長尺管の略管長方向に回転可能な拡径ローラが配設されていることを特徴とする拡管マンドレル。

【請求項２】　前記拡径ローラは、マンドレル本体の周方向に等間隔に複数配設されていることを特徴とする請求項１に記載の拡管マンドレル。

【請求項３】　前記拡管マンドレル本体は、長尺管に挿通される先端部より基端部に向けて漸次大径となるように多段階的に形成され、その各径部に前記拡径ローラが周方向に等間隔に夫々複数設けられていることを特徴とする請求項１又は２に記載の拡管マンドレル。

【請求項４】　前記拡管マンドレル本体は、進退動自在かつ回転自在なブランジャの先端に設けられ、前記拡径ローラの回転方向は該ブランジャの前進回転動に対応して長尺管の管長方向に対してやや傾きを持って設けられていることを特徴とする請求項１、２又は３に記載の拡管マンドレル。

【請求項５】拡管されるべき長尺管の一方の開口端より拡管マンドレルを挿通し、該拡管マンドレルの外周面に設けられる拡径ローラにより前記長尺管の内壁面を外方へ押圧するようにした長尺管の拡管方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、鋼材による長尺管を拡管するのに好適な拡管マンドレル及びそれを用いた長尺管の拡管方法に関するものである。

【０００２】

【従来の技術】従来、鋼材による長尺管を拡管するに際しては、例えば、図４に示したようなテーパ付拡管マンドレルを使用して拡管することが行なわれている。これは、長尺管２６の一方の開口端より図示のテーパ付拡管マンドレル２０を挿通し、所定の荷重Ｐを印加しながらこの拡管マンドレル２０を長尺管２６に押し込むことにより、この拡管マンドレル２０のテーパ部２２から大径部２４の部分で長尺管２６の内壁面を外方へ押圧し、拡管しながら長尺管２６内を前進させるものである。

【０００３】これに関する技術はいくつかの特許公報に既に示されており、例えば、特開平７－１４８５１６号公報は、長尺管をダイスによって引き抜くに際し、長尺管内に心金（マンドレル）を通して拡管と引抜きとを同時に行なうものである。

【０００４】また例えば、特表平５０７６１０号公報（国際公開番号ＷＯ９３／２５７９９）には、石油掘削パイプを地中のボアホール内で拡管するに際し、拡管マンドレルを引き上げながら拡管するものである。更に、国際公開ＷＯ９８／００６２６号公報のものも同様に石油掘削パイプに拡管マンドレルを通して拡管するもので、この公報のものは拡管マンドレルの外周面にセラミックスをコーティーングすることにより拡管時の摩擦抵抗を小さくしようとするものである。

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【０００５】

【発明が解決しようとする課題】しかしながら、このような従来一般に知られる拡管マンドレル（テーパ付のものを含む）によれば、いずれもマンドレルに加えた荷重により長尺管の内壁面を押圧し拡径しようとするものであるから、長尺管の内壁面とマンドレルとの間の摩擦抵抗力が大きく、マンドレルがスムーズに動かず、加工スピードが遅いという問題がある。

【０００６】また、このように長尺管とマンドレルとの摩擦抵抗力が大きいことで摩擦熱が発生し、マンドレルに印加される荷重が十分に長尺管の拡管力として伝達されずエネルギー効率が悪いという問題もある。更に、かかる摩擦抵抗によってマンドレルがスムーズに動かずに間歇的な前進運動を繰り返して不連続に移動するため、拡管された長尺管の外径が一定せず表面が波打現象を起こしたり、或いは、摩擦抵抗によって長尺管に加工歪みが生じるといった問題が懸念されるものであった。

【０００７】本発明の解決しようとする課題は、鋼材等の長尺管を拡管するに際してその拡管スピードを上げることができ、しかも、長尺管とマンドレルとの摩擦抵抗を小さくして加工によるエネルギー効率を高め、更に品質面でも拡管表面の波打ち等もない拡管マンドレル及び、それを用いた長尺管の拡管方法を提供することにある。

【０００８】

【課題を解決するための手段】この課題を解決するために本発明の拡管マンドレルは、鋼材による長尺管に挿通される拡管マンドレル本体の外周面に、該長尺管の内壁面に圧接され、かつ、その長尺管の略管長方向に回転可能な拡径ローラが配設されていることを要旨とするものである。

【０００９】上記構成を有する本発明の拡管マンドレルによれば、鋼材による長尺管に挿通し牽引又は押し込むことによりマンドレル本体の外周面に設けられる拡径ローラがその長尺管の内壁面に圧接された状態でその略管長方向に回転しながら前進していく。そのために長尺管の内壁面が半径方向へ押し広げられて塑性変形して拡管される。

【００１０】その際に、前記拡径ローラが前記長尺管の内壁面を回転しながら拡管されるものであるから、長尺管の内壁面と拡管マンドレルとの間の摩擦抵抗は非常に小さい。そのために拡管マンドレルが長尺管内を低い移動抵抗でスムーズに移動することができるので、加工スピードを上げることができ、また、拡管マンドレルの挿通に必要な牽引力又は押進力は小さくて済むようになり、摩擦熱などの発熱も生じることなくエネルギー効率が高められることになる。また、摩擦抵抗によってマンドレルがスムーズに動かないことによって生じる長尺管

表面の波打ち現象もなくなり、加工精度を向上させることができる。

【００１１】この場合に、前記拡径ローラをマンドレル本体の周方向に複数等間隔に配設するようにすれば、長尺管の内壁面が周方向均等に分散された拡管力によって拡径されるのでその拡径された長尺管の断面形状の真円度が増し、寸法精度良く拡径することができる。

【００１２】この場合に、前記拡管マンドレル本体は、長尺管に挿通される先端部より基端部に向けて漸次大径となるように多段階的に形成され、その各径部に前記拡径ローラが周方向に等間隔に夫々複数設けられるようにするとよい。そうすれば、長尺管の拡径が多段階に分けて徐々に行なわれることになり、その分各段階における摩擦抵抗が減少し、拡径ローラの負荷も軽減され、加工スピードを上げることができる。

【００１３】そして更に、前記拡管マンドレル本体は、進退動自在かつ回転自在なプランジャの先端に設けられ、前記拡径ローラの回転方向は該プランジャの前進回転動に対応して長尺管の管長方向に対してやや傾きを持って設けられるようにするとよい。そうすれば、拡管マンドレルがプランジャの前進と回転によって長尺管内を前進しながら周方向にも回転することになり、それによって拡径ローラが長尺管の内壁面に均等に圧接されて真円度の高い長尺管が得られることになる。また、拡管マンドレルが長尺管内を回転しながら前進移動するので、その進行方向への移動がスムーズに行なわれ、速やかに拡管が行なわれることになる。

【００１４】そして本発明に係る長尺管の拡管方法は、拡管されるべき長尺管の一方の開口端より拡管マンドレルを挿通し、該拡管マンドレルの外周面に設けられる拡径ローラにより前記長尺管の内壁面を外方へ押圧するようにしたことを要旨とするものである。

【００１５】この場合にも請求項２又は３に記載のように、拡径ローラがマンドレル本体の周方向に等間隔に複数配設され、あるいは、拡管マンドレル本体が長尺管に挿通される先端部より基端部に向けて漸次大径となるように多段階的に形成され、その各径部に前記拡径ローラが周方向に等間隔に夫々複数設けられており、更に請求項４に記載のように拡管マンドレル本体が進退動自在かつ回転自在なプランジャの先端に設けられ拡径ローラの回転方向は該プランジャの前進回転動に対応して長尺管の管長方向に対してやや傾きを持って設けられておれば、エネルギー効率良くスムーズに拡管加工が行なわれ、その加工寸法精度が優れたものになることは上述した通りである。

【００１６】

【発明の実施の形態】以下に本発明の好適な実施の形態を図面を参照して詳細に説明する。図１は、本発明の一実施の形態に係る拡管マンドレルを拡径される長尺管に挿通した状態の外観図を示したものである。長尺管に関しては断面図となっている。この拡管マンドレル２０は、図示しない油圧シリンダのプランジャ２４の先端に一体的に設けられ、そのマンドレル本体２５は長尺管２６に挿通される先端部分からプランジャ側の其端部分にかけて第１の径部２１ａから第５の径部２１ｅまで多段階的にその径を徐々に大きくしている。そして各径部２１ａ～２１ｅの間はテーパ状になっている。

【００１７】前記マンドレル本体２５の各径部２１ａ～２１ｅには夫々長尺管２６の内壁面に圧接され、かつ、前記プランジャ２４の伸長動によって長尺管２６の略管長方向に回転可能な拡径ローラ２３が複数個づつ（この実施例では４個づつ）周方向に等間隔に設けられている。尚、前記プランジャ２４は、図示されるように長尺管２６内を進退動と回転動とを行なうように構成されている。

【００１８】図２は、図１に示した拡管マンドレルの管長方向の断面図を示したものである。前記拡径ローラ２３は第２の径部２１ｂから第５の径部２１ｅの夫々の外周を４等分する位置に設けられる拡径ローラ取付穴に１個づつ配設されており、その回転方向は長尺管の管長方向に対してやや傾いた方向に設けられて前記プランジャ２４の前進（矢示Ｃ方向）と回転（矢示Ｄ方向）の組み合わせによるマンドレル本体２５のスパイラル回転方向（矢示Ｂ方向）とは逆方向（矢示Ｂ方向とは逆方向）に拡径ローラ２３は内壁面に圧接されながら前進するように構成されている。

【００１９】そして第２の径部２１ｂ及び第４の径部２１ｄに夫々設けられる４個の拡径ローラ２３の配設位置と第３の径部２１ｃ及び第５の径部２１ｅに夫々設けられる４個の拡径ローラの配設位置とは図示のように円周方向に角度で４５度ずれて互い違いに設けられている。そして各拡径ローラ２３は、長尺管２６の内壁面に圧接され、その内壁面を半径方向外方へ押圧拡張し塑性変形させながら、長尺管の管長方向に対してやや傾きを持つ矢印Ｂの方向へ回転しつつ前進するように構成されるものである。

【００２０】図３は、前記図１に示した拡管マンドレルの管長方向に直交する方向（管径方向）の断面図を示したものである。該拡管マンドレル２０の本体２５の径部２１ｂには円周方向に等間隔に４個の拡径ローラ２３が配設されている。各拡径ローラ２３は、拡管マンドレル本体２５が前記プランジャ２４の伸長動及び回転動に対応してスムーズに回転しながら前進運動を行なえるように、長尺管２６の内接面に圧接されて拡径ローラ２３が進行する方向が管長方向に対して夫々傾いた方向となるように配設される。

【００２１】例えば、図３において上方に配設される拡径ローラ２３はその回転軸の右方端の取付位置が左方端の取付位置よりも図面に向かって手前になるように設けられる。同様にして、他の拡径ローラ２３についても夫

々の回転軸の右回りの方の端部の取付位置が左回りの方の端部の取付位置よりも手前になるように設けられている。

【００２２】しかしてこのように構成された拡管マンドレル２０を用いて鋼材による長尺管２６を拡管するに際しては、この拡管マンドレル２０を図１及び図２に示したように長尺管２６内の一方の開口端より挿通し、図示しない油圧シリンダによりプランジャ２４を回転させながら前進させることにより、第１段階としてこの拡管マンドレル２０の第２の径部２１ｂに設けられる４個の拡径ローラ２３が長尺管２６の内壁面に圧接され、その各拡径ローラ２３の回転に伴なってその各拡径ローラ２３が圧接される部分の長尺管２６の管壁がその径方向外方へ押し広げられる。

【００２３】次いで、その長尺管２６の拡径された内壁面には該拡管マンドレル２０の第３の径部２１ｃに設けられる４個の拡径ローラ２３が圧接され、その部分の管壁がその径方向外方へ押し広げられる。更に、その長尺管２６の拡径された内壁面には該拡管マンドレル２０の第４の径部２１ｄに設けられる４個の拡径ローラ２３が圧接され、その部分の管壁がその径方向外方へ押し広げられる。

【００２４】最終段階として、その長尺管２６の拡径された内壁面には該拡管マンドレル２０の第５の径部２１ｅに設けられる４個の拡径ローラ２３が圧接され、その部分の管壁がその径方向外方へ押し広げられる。こうして、本実施の形態の拡管マンドレル２０を長尺管２６の全体に挿通させると、全体が拡径された円形断面の長尺管２６が得られ、その内径は第５の径部２１ｅに設けられる４個の拡径ローラに外接する円の径とほぼ等しくなる。

【００２５】そして、このように拡管マンドレル２０の第２～第５の各径部２１ｂ～２１ｅに夫々設けられる拡径ローラ２３、２３・・・により長尺管２６が多段階にわたって徐々に拡管され、その間拡径ローラ２３、２３・・・は長尺管２６の内壁面を回転しながら前進していくものであるから、長尺管２６の内壁面と拡径ローラ２３、２３・・・との間の摩擦抵抗は少なく、スムーズな拡管加工が行われる。

【００２６】また、その摩擦抵抗が少ないことにより、長尺管２６の内壁面あるいは拡管マンドレル２０のマンドレル本体２５や拡径ローラ２３、２３・・・に摩擦熱の発生はほとんどないことから、拡管加工に伴なうエネルギー損失も生じず、その分この拡管マンドレル２０を前進させる油圧シリンダ等の負荷も小さくて済むことになる。

【００２７】さらに、長尺管２６内で拡管マンドレルの前進動がスムーズに行なわれることから、拡管時の管表面の波打ち現象も起こることはなく、径寸法精度の優れたものが得られることになる。

【００２８】本発明は、前記した実施の形態に何ら限定されるものではなく、本発明の趣旨を逸脱しない範囲で種々の改変が可能である。例えば、前記実施の形態では、拡管マンドレルをプランジャの伸長動により長尺管に押し込み拡径する構成を示したが、拡管マンドレルが収縮動により牽引されて拡管するような構成とすることもできる。また、マンドレル本体の各径部に配設される拡径ローラの数も４個づつとは限らず、３個又は５個以上配設することも可能であり、拡管マンドレルの夫々の径部に配設する拡径ローラの個数が多いほど、それを用いて拡管された長尺管の断面形状がより真円に近くなることは言うまでもない。

【００２９】また、前記実施の形態では各段階の径部に一列に拡径ローラを配設したが、複数列に、かつ各列の配設位置を互いにずらして配設すれば、より多くの拡径ローラを拡管マンドレルの円周に等間隔に配設することができ、その拡管マンドレルを用いることにより加工後の長尺管断面の真円度を上げることができる。一方、マンドレル本体２５の全体形状を、その径が先端部から其端部へ向けて徐々に小径から大径になるようなテーパ形状に構成してもよい。

【００３０】

【発明の効果】本発明の拡管マンドレル及びこれを用いた拡管方法によれば、鋼材による長尺管を拡管するに際し、拡管マンドレル本体の外周面に設けられる拡径ローラにより長尺管の内壁面を外方向へ押圧し、その拡径ローラの回転により長尺管内を前進させていくものであるから、拡管時の摩擦抵抗を少なくして、摩擦熱の発生を減少させることができるため加工のエネルギー効率の向上を図ることができる。また、拡管マンドレルが長尺管内をスムーズに移動できるので管表面の波打ち等の発生防止、加工スピードの向上が図られ、石油掘削パイプの拡管作業等に適用することは極めて有効である。

【００３１】尚、請求項２に記載の発明のように、拡径ローラをマンドレル本体の周方向に等間隔に複数配設するようにすれば、その拡径された長尺管の断面形状の真円度が増し、寸法精度良く拡径することができ、また、請求項３に記載の発明のように、拡管マンドレル本体が、長尺管に挿通される先端部より基端部に向けて漸次大径となるように多段階的に形成され、その各径部に前記拡径ローラが周方向に等間隔に夫々複数設けられたものでは、各段階の拡径ローラの負荷が軽減され加工スピードを上げることができる。

【００３２】更に請求項４に記載の発明のように、拡管マンドレル本体が、進退動自在かつ回転自在なプランジャの先端に設けられ、前記拡径ローラの回転方向は該プランジャの前進回転動に対応して長尺管の管長方向に対してやや傾きを持って設けられておれば、拡管マンドレルを長尺管内の周方向に回転させながら前進させていったときに、拡径ローラが長尺管の内壁面に均等にあたり、

真円度の高い長尺管が得られるとともに、その進行方向への移動がスムーズに行なわれ、速やかに拡管を行なうことができる利点を有する。

【図面の簡単な説明】

【図1】本発明一実施の形態に係る拡管マンドレルを拡径される長尺管に挿通した状態の外観図である。

【図2】図1に示した拡管マンドレルの管長方向の断面図である。

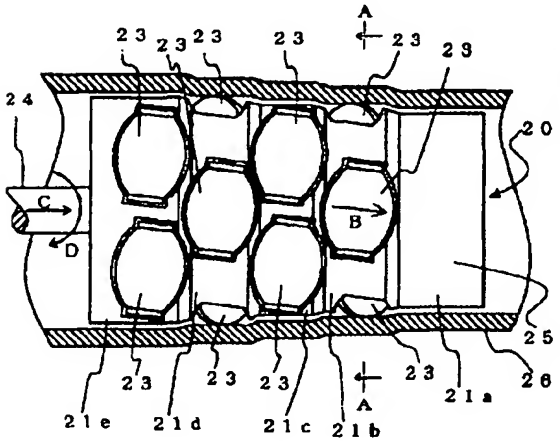
【図3】図1に示した拡管マンドレルの管長方向に直交する方向（管径方向）の断面図である。

＊【図4】従来一般に知られるテーパ付き拡管マンドレルの外観図である。

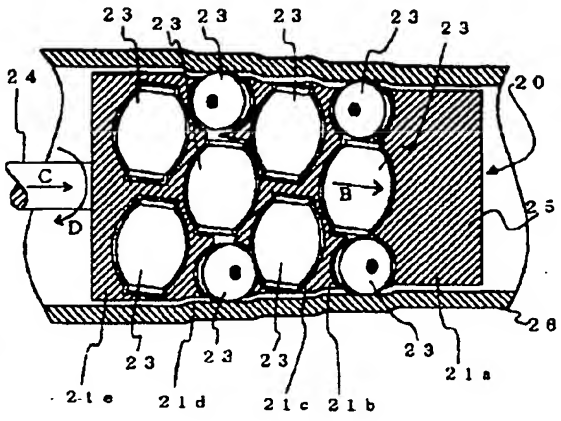
【符号の説明】

20 拡管マンドレル
21 径部
23 拡径ローラ
24 ブランジャ
25 拡管マンドレル本体
26 長尺管

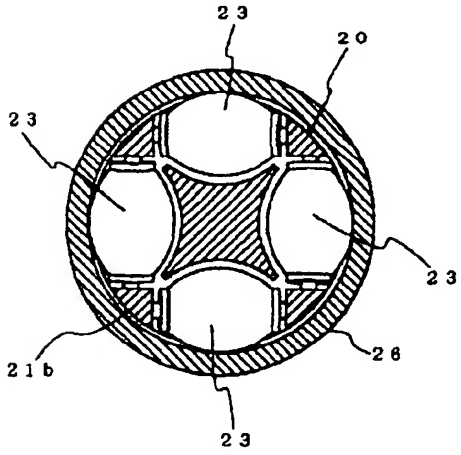
【図1】



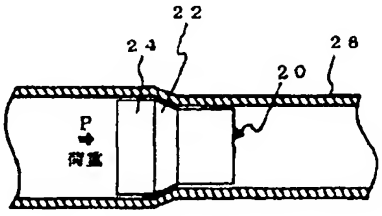
【図2】



【図3】



【図4】



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(54) Title of the Invention: EXPANSION MANDREL AND EXPANSION METHOD FOR LONG PIPE THAT USES THE EXPANSION MANDREL

(57) Summary
(Problem)
Provide (1) an expansion mandrel that, when expanding a long pipe made of steel, has small frictional resistance and is energy efficient, with which it is possible to perform processing superior with respect to dimensional accuracy, and (2) an expansion method for a long pipe that uses this expansion mandrel.

(Means for Solving)
Pass expansion mandrel 20 through one of the opening ends of long pipe 26 made of steel, and while advancing/revolving this expansion mandrel 20, pressure weld to the interior surface of long pipe 26 a plurality of radial expansion rollers 23, 23, ..., which are established on the periphery of expansion mandrel main body 25, and radially expand by spreading outward in the radial direction of this long pipe 26.

[see source for drawing]

(Scope of Patent Claims)

(Claim 1)
Expansion mandrel in which radial expansion rollers, which are pressure welded to the interior surface of a long pipe made of steel and are revolvable in the rough pipe length direction of that long pipe, are arranged on the periphery of the expansion mandrel main body that is passed into the long pipe.

(Claim 2)
The expansion mandrel according to Claim 1, wherein said radial expansion rollers are multiply established at equal intervals in the circumferential direction of the mandrel main body.

(Claim 3)
The expansion mandrel according to either Claim 1 or Claim 2, wherein said expansion mandrel main body is formed in a multistage manner such that the radius progressively increases towards the rear edge from the front edge that is passed into the long pipe, and said radial expansion rollers are multiply established circumferentially at equal intervals on each radial region.

(Claim 4)
The expansion mandrel according to Claim 1, Claim 2, or Claim 3, wherein said expansion mandrel main body is established on the tip of a plunger that can advance and retreat freely and can revolve freely, and the revolution direction of said radial expansion rollers is established having a slight inclination with respect to the pipe length direction of the long pipe corresponding to said forward revolution of the plunger.

(Claim 5)
Expansion method for long pipe in which the expansion mandrel is passed through one of the opening ends of the long pipe to be expanded, and the interior surface of said long pipe is pressed outward by radial expansion rollers that are established on the periphery of the expansion mandrel.

(Detailed Description of the Invention)

(0001)
(Technical Field of the Invention)
The present invention is related to an expansion mandrel that is ideal for expanding long pipe made of steel, and the expansion method for long pipe that uses this expansion mandrel.

(0002)
(Prior Art)
Conventionally, when expanding long pipe made of steel, expansion is performed by using a tapered expansion mandrel such as that shown in Figure 4, for example. With this, the indicated tapered expansion mandrel 20 is passed through one of the opening ends of long pipe 26, and by driving this expansion mandrel 20 into long pipe 26 while applying prescribed load P, the interior surface of long pipe 26 is pressed outward with the large radius region 24 from the tapered region 22 of this expansion mandrel 20, and it is advanced through the interior of long pipe 26 interior while expanding.

(0003)
Technology related to this has been previously shown in numerous patent publications, and Unexamined Patent Application Publication H7-148516, for example, is an invention that, when extracting the long pipe with a die, performs expansion and extraction simultaneously by passing a core bar (mandrel) through the inside of the long pipe.

(0004)
Moreover, Published Japanese Translation of a PCT Application H-507610 (International Publication Number WO93/25799) documents an invention that, when expanding an oil drilling pipe with the borehole interior underground, expands while drawing the expansion mandrel up. Furthermore, the invention of International Publication WO98/00626 likewise expands by passing an expansion mandrel through the oil-drilling pipe, and the invention of this publication attempts to reduce the frictional resistance at the time of expansion by coating the periphery of the expansion mandrel with ceramics.

(0005)
(Problems Addressed by the Invention)
However, through such generally known conventional expansion mandrels (including tapered mandrels), because all of them attempt to radially expand by pressing the interior surface of the long pipe with a load added to the mandrel, there are problems in which the frictional resistance between the interior surface of the long pipe and the mandrel is large, the mandrel does not move smoothly, and processing speed is slow.

(0006)
Moreover, there are also problems in which frictional heat is generated due to the fact that the frictional resistance between the long pipe and the mandrel is large; in this way, the load applied to the mandrel is not sufficiently transmitted as the expansion force of the long pipe and the energy efficiency is low. Furthermore, there was also fear of the problem in which, because the mandrel does not move smoothly due to the frictional resistance and travels discontinuously by repeating intermittent thrusting movements, the external diameter of the expanded long pipe is not constant and a rippling phenomenon occurs on the surface, or processing deformations develop on the long pipe due to frictional resistance.

(0007)
The problems addressed by the present invention are to enable the increase of expansion speed when expanding long pipe made of steel or other material, reducing the frictional resistance between the long pipe and the mandrel and raising energy efficiency through processing, further providing an expansion mandrel without ripples on the expansion surface from the perspective of quality, and providing an expansion method for long pipe that uses this expansion mandrel.

(0008)
(Means for Solving the Problems)
In order to solve these problems, the expansion mandrel of the present invention is summarized in that radial expansion rollers, which are pressure welded to the interior surface of a long pipe made of steel and are revolvable in the rough pipe length direction of that long pipe, are arranged on the periphery of the expansion mandrel main body that is passed into the long pipe.

(0009)
Through the expansion mandrel of the present invention that has the aforementioned configuration, by passing the mandrel through a long pipe made of steel and pulling or driving it, the radial expansion rollers that are established on the periphery of the mandrel main body advance while revolving in the rough pipe length direction in the state in which they are pressure welded to the interior surface of that long pipe. Therefore, the interior surface of the long pipe is spread out in the radial direction, plastic deformed, and expanded.

(0010)
At that time, because it is expanded while said radial expansion rollers revolve the interior surface of said long pipe, the frictional resistance between the interior surface of the long pipe and the expansion mandrel is extremely small. Therefore, the expansion mandrel is able to move smoothly through the inside of the long pipe with low movement resistance, so it is possible to increase processing speed. Furthermore, the tractive force and the pressing force necessary to insert the expansion mandrel can be small, and energy efficiency can thus be increased without the generation of heat such as frictional heat. Moreover, this eliminates the rippling phenomenon that occurs on the surface of the long pipe due to the fact that the mandrel does not move smoothly due to frictional resistance, and it is thus possible to improve processing accuracy.

(0011)
In this case, if said radial expansion rollers are multiply arranged at equal intervals in the circumferential direction of the mandrel main body, the interior surface of the long pipe will radially expand through the expansion force that is uniformly dispersed circumferentially, so it will be possible to increase the circularity of the cross sectional shape of this radially expanded long pipe, and to radially expand with high dimensional accuracy.

(0012)
In this case, said expansion mandrel main body should be formed in a multistage manner such that the radius progressively increases towards the rear edge from the front edge that is passed into the long pipe, and said radial expansion rollers should be multiply established circumferentially at equal intervals on each radial region. By doing so, the radial expansion of the long pipe is divided into multiple stages and performed gradually. Accordingly, the frictional resistance in each stage is reduced, the load of the radial expansion rollers is lightened, and it is possible to increase the processing speed.

(0013)
Furthermore, said expansion mandrel main body should be established on the tip of a plunger that can advance and retreat freely and can revolve freely, and the revolution direction of said radial expansion rollers should be established having a slight inclination with respect to the pipe length direction of the long pipe corresponding to said advancement/revolution of the plunger. By doing so, the expansion mandrel also revolves circumferentially while advancing through the inside of the long pipe through the advancement and revolution of the plunger, and the radial expansion rollers are thereby uniformly pressure welded to the interior surface of the long pipe and it is possible to obtain a long pipe that has high circularity. Moreover, because the expansion mandrel travels forward through the inside of the long pipe while revolving, movement in that traveling direction is performed smoothly, and expansion is performed quickly.

(0014)
The expansion method for long pipe of the present invention is summarized in that the expansion mandrel is passed through one of the opening ends of the long pipe to be expanded, and the interior surface of said long pipe is pressed outward by radial expansion rollers that are established on the periphery of the expansion mandrel.

(0015)
In this case as well, if the system is configured such that (1) as in Claim 2 or Claim 3, the radial expansion rollers are multiply established at equal intervals in the circumferential direction of the mandrel main body, or the expansion mandrel main body is formed in a multistage manner such that the radius progressively increases towards the rear edge from the front edge that is passed into the long pipe, and said radial expansion rollers are multiply established circumferentially at equal intervals on each radial region, and furthermore, (2) as described in Claim 4, the expansion mandrel main body is established on the tip of a plunger that can advance and retreat freely and can revolve freely, and the revolution direction of the radial expansion rollers is established having a slight inclination with respect to the pipe length direction of the long pipe corresponding to said forward revolution of the plunger, then expansion processing will be performed energy efficiently and smoothly, and it will be superior with respect to processing dimensional accuracy as described above.

(0016)
(Embodiments of the Invention)
An ideal embodiment of the present invention is described in detail below with reference to the drawings. Figure 1 shows an outline view of the state in which the expansion mandrel of one example of embodiment of the present invention passes into the long pipe that is radially expanded. It shows a cross sectional view with regard to the long pipe. This expansion mandrel 20 is integrally established on the tip of plunger 24 on a hydraulic cylinder that is not shown in the figure, and the mandrel main body 25 gradually increases the diameter in a multistage manner from the first radial region 21a to the fifth radial region 21e between the front edge that is passed into long pipe 26 and the rear edge of the plunger side. Then the spaces between each radial region 21a ~ 21e take tapered shapes.

(0017)
Radial expansion rollers 23, which are each pressure welded to the interior surface of long pipe 26 and are revolvable in the rough pipe length direction of pipe 26 through the extension movement of said plunger 24, are multiply established (four rollers each in this example of embodiment) circumferentially at equal intervals on each radial region 21a ~ 21e of said mandrel main body 25. Moreover, said plunger 24 is configured such that it performs the advancing and retreating movement and the revolving movement through the inside of long pipe 26 as shown.

(0018)
Figure 2 shows a cross sectional view of the pipe length direction of the expansion mandrel shown in Figure 1. One each of said radial expansion rollers 23 is arranged in the radial expansion roller mounting holes that are established in positions that divide each of the peripheries of the second radial region 21b to the fifth radial region 21e into four equal parts. The revolution direction is established in a slightly inclined direction with respect to the pipe length direction of the long pipe, and radial expansion rollers 23 are configured such that they advance in the opposite direction (the opposite direction of the direction indicated

by arrow B) with respect to the spiral revolution direction (the direction indicated by arrow B) of mandrel main body 25 through the combination of the advancement (the direction indicated by arrow C) and revolution (the direction indicated by arrow D) of said plunger 24.

(0019)
As for the arrangement positions of the four radial expansion rollers 23 that are arranged on each of the second radial region 21b and the fourth radial region 21d and the arrangement positions of the four radial expansion rollers that are established on each of the third radial region 21c and the fifth radial region 21e, they are established alternately shifted by 45° angles in the circumferential direction. Each of the radial expansion rollers 23 are pressure welded to the interior surface of long pipe 26, and they are configured such that they, while pressure expanding this interior surface outward in the radial direction and plastic deforming it, advance while revolving in the direction of arrow B, which has a slight inclination with respect to the pipe length direction of the long pipe.

(0020)
Figure 3 shows a cross sectional view of the direction (pipe radial direction) that is orthogonal to the pipe length direction of said expansion mandrel shown in Figure 1. Four radial expansion rollers 23 are arranged circumferentially at equal intervals on radial region 21b of main body 25 of this expansion mandrel 20. Each of the radial expansion rollers 23 are pressure welded to the interior surface of long pipe 26 such that the expansion mandrel main body 25 can perform the thrusting movement while smoothly revolving in accordance with the extension movement and the revolution movement of said plunger 24, and they are arranged such that the directions in which the radial expansion rollers 23 advance are directions that are each inclined with respect to the pipe length direction.

(0021)
For example, the radial expansion roller 23 that is arranged on the upper portion in Figure 3 is established such that the mounting position of the right-hand edge of the revolution axis is more in the foreground facing the figure than the mounting position of the left-hand edge. Likewise, the other radial expansion rollers 23 are also each established such that the mounting position of the edge in the clockwise direction of the revolution axis is more in the foreground than the mounting position of the edge in the counterclockwise direction.

(0022)
Therefore, when using an expansion mandrel 20 that has been configured in this way to expand a long pipe 26 made of steel, by passing this expansion mandrel 20 into one of the opening ends of the inside of long pipe 26 as shown in Figure 1 and Figure 2 and advancing plunger 24 while revolving it with a hydraulic cylinder not shown in the figure, as the first stage, the four radial expansion rollers 23 that are established on the second radial region 21b of this expansion mandrel 20 are pressure welded to the interior surface of long pipe 26, and in step with the revolution of each of these radial expansion rollers 23, the pipe wall of the portion of long pipe 26 to which each of these radial expansion rollers 23 was welded are spread radially outward.

(0023)
Next, the four radial expansion rollers 23 that are established on the third radial region 21c of this expansion mandrel 20 are pressure welded to the radially expanded interior surface of this long pipe 26, and the pipe wall of this portion is spread radially outward. Furthermore, the four radial expansion rollers 23 that are established on the fourth radial region 21d of this expansion mandrel 20 are pressure welded to the radially expanded interior surface of this long pipe 26, and the pipe wall of this portion is spread radially outward.

(0024)
As the final stage, the four radial expansion rollers 23 that are established on the fifth radial region 21e of this expansion mandrel 20 are pressure welded to the radially expanded interior surface of this long pipe 26, and the pipe wall of this portion is spread radially outward. Circular cross section long pipe 26, in which the entire length is radially expanded, is obtained by passing the expansion mandrel 20 of this embodiment into the entire long pipe 26 in this way. The interior diameter becomes approximately equal to

a circle circumscribed around the four radial expansion rollers that are established on the fifth radial region 21e.

(0025)
Next, long pipe 26 is gradually expanded in a multistage manner by radial expansion rollers 23, 23 ..., which are respectively established on the second through fifth radial regions 21b ~ 21e of the expansion mandrel 20. During this time, because radial expansion rollers 23, 23... advance through the interior surface of long pipe 26 while rotating, the frictional resistance between the interior surface of long pipe 26 and radial expansion rollers 23, 23... is small, and smooth expansion processing can thus be conducted.

(0026)
Moreover, because there is almost no generation of frictional heat on the interior surface of long pipe 26 or mandrel main body 25 of expansion mandrel 20 or radial expansion rollers 23, 23... due to the fact that this frictional resistance is small, [sic] there is no energy loss accompanying expansion processing, and therefore the load of the hydraulic cylinder that advances this expansion mandrel 20, for example, can be small.

(0027)
Furthermore, because the advancing movement of the expansion mandrel is performed smoothly within long pipe 26, there is no occurrence of the rippling phenomenon on the pipe surface at the time of expansion, and pipe that is superior with respect to radial dimensional accuracy can be obtained.

(0028)
The present invention is not limited to the previously described embodiment, and various alterations are possible to an extent that does not deviate from the purport of the present invention. For example, the previously described embodiment shows a configuration that expands by driving an expansion mandrel into the long pipe through extension movements of a plunger, but a configuration that expands by pulling the expansion mandrel through constriction movements is also possible. Moreover, the number of radial expansion rollers that are arranged on each radial region of the mandrel main body is not limited to four each, and it is also possible to arrange three rollers or five or more rollers. It goes without saying that the greater the number of radial expansion rollers arranged on each radial region of the expansion mandrel, the closer the cross sectional shape of a long pipe that uses the mandrel will be to a perfect circle.

(0029)
Furthermore, radial expansion rollers were arranged in a row on the radial regions of each stage in the previously described embodiment, but if they are arranged in multiple rows with the arrangement positions of each row mutually out of phase, it is possible to arrange a greater number of radial expansion rollers at equal intervals on the periphery of the expansion mandrel, and by using this expansion mandrel, it is possible to increase the circularity of the long pipe cross section following processing. Moreover, it would be acceptable to configure the entire shape of mandrel main body 25 into a tapered shape such that the diameter gradually changes from a small diameter to a large diameter from the front edge to the rear edge.

(0030)
(Effects of the Invention)
Through the expansion mandrel and the expansion method that uses this mandrel in the present invention, when expanding long pipe made of steel, the interior surface of the long pipe is pressed outward by radial expansion rollers that are established on the periphery of the expansion mandrel main body and it is advanced through the inside of the long pipe through the revolution of the radial expansion rollers, so the frictional resistance at the time of expansion is small, and it is possible to improve the processing energy efficiency because it is possible to reduce the occurrence of frictional heat. Furthermore, the expansion mandrel is able to travel smoothly through the inside of the long pipe, so the processing speed and the prevention of the generation of ripples on the pipe surface are improved, and it is extremely effective to apply it to the expansion operation for oil drilling pipe, for example.

(0031)
Moreover, as with the invention described in Claim 2, if radial expansion rollers are multiply arranged at equal intervals in the circumferential direction of the mandrel main body, the circularity of the cross sectional shape of the expanded long pipe increases, and it is possible to expand with good dimensional accuracy. Furthermore, as with the invention described in Claim 3, with an invention in which the expansion mandrel main body is formed in a multistage manner such that the radius progressively increases towards the rear edge from the front edge that is passed into the long pipe, and said radial expansion rollers are multiply established circumferentially at equal intervals on each radial region, the loads of the radial expansion rollers of each stage are reduced and it is possible to increase the processing speed.

(0032)
Furthermore, as with the invention described in Claim 4, if the expansion mandrel main body is established on the tip of a plunger that can advance and retreat freely and can revolve freely, and the revolution direction of said radial expansion rollers is established having a slight inclination with respect to the pipe length direction of the long pipe corresponding to said forward revolution of the plunger, then when advancing the expansion mandrel through the inside of the long pipe while rotating circumferentially, the radial expansion rollers make contact uniformly with the interior surface of the long pipe, and in addition to obtaining a long pipe with high circularity, the invention has the advantages that movement in this travel direction is performed smoothly and expansion is performed quickly.

(Brief Description of the Figures)

(Figure 1)
Outline view of the state in which the expansion mandrel of one embodiment of the present invention passes into the long pipe that is radially expanded.

(Figure 2)
Cross sectional view of the pipe length direction of the expansion mandrel shown in Figure 1.

(Figure 3)
Cross sectional view of the direction (pipe radial direction) that is orthogonal to the pipe length direction of the expansion mandrel shown in Figure 1.

(Figure 4)
Outline view of the generally known conventional tapered expansion mandrel.

(Explanation of the Symbols)

20	Expansion Mandrel
21	Radial Region
23	Radial Expansion Roller
24	Plunger
25	Expansion Mandrel Main body
26	Long Pipe

[see source for figures]

(Figure 1)

(Figure 2)

(Figure 3)

(Figure 4)

Load P

TRANSPERFECT | TRANSLATIONS

AFFIDAVIT OF ACCURACY

I, Kim Stewart, hereby certify that the following is, to the best of my knowledge and belief, true and accurate translations performed by professional translators of the following patents/abstracts from Japanese to English:

Patent 64-75715
Patent 2000-94068
Patent 2000-107870

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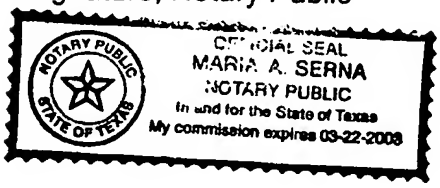

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